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(54) Improvements in or relating to  
 arrangements for charging  
 storage batteries

(57) A battery charger (1) comprises a  
 primary circuit (2) and a secondary  
 circuit (3) inductively coupled thereto.  
 The secondary circuit (3) can be  
 spatially separated from the primary  
 circuit (2). The primary circuit (2)  
 comprises a rectifier (10), which  
 rectifies the low-frequency supply

voltage (U). This direct current voltage  
 is used to feed an LC oscillator (15). The  
 inductor (19) of the series oscillatory  
 circuit (21) of this oscillator (15) forms  
 the primary winding of a transformer  
 (24), the secondary winding (25) of  
 which is arranged in the secondary  
 circuit (3). This secondary winding (25)  
 is connected to a rectifier (26). The  
 storage battery (31) which is to be  
 recharged is connected to the output  
 terminals (29, 30) of the secondary  
 circuit (3). The oscillator (15) produces a  
 high-frequency alternating current  
 voltage, which is transformed to the  
 secondary side of the transformer (24)  
 and subsequently rectified.

The battery charger (1) is particularly  
 suitable for use with electrically driven  
 dental care appliances, especially  
 toothbrushes. In this case the primary  
 circuit (2) is accommodated in a holder  
 for the dental care appliance, while the  
 secondary circuit (3) is arranged inside  
 the dental care appliance.

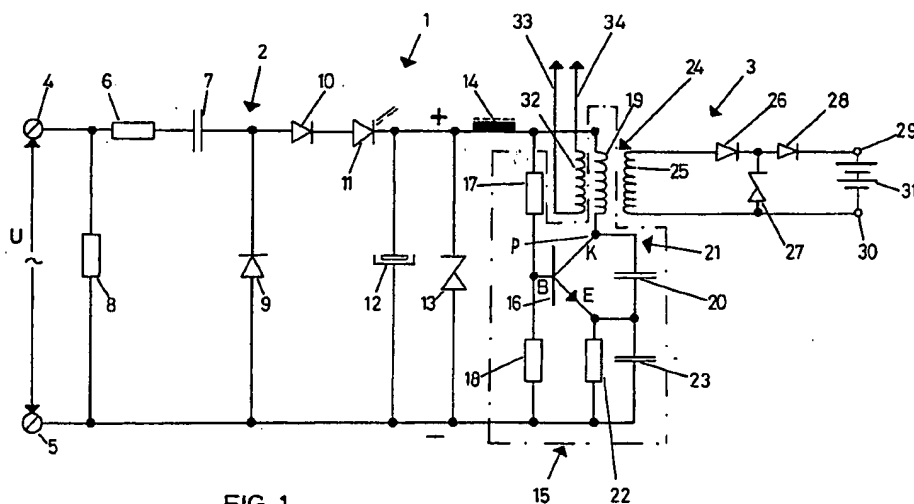


FIG. 1

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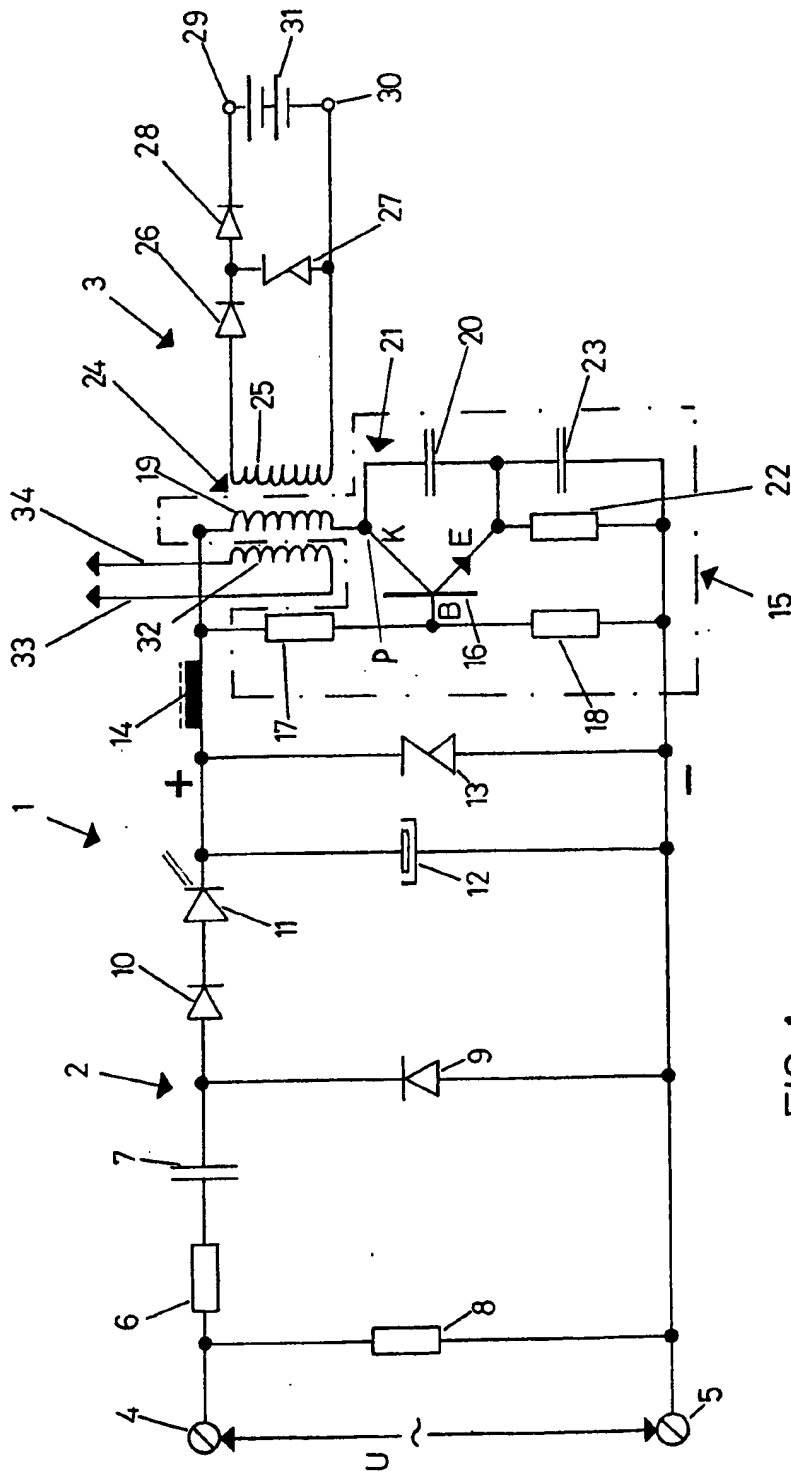
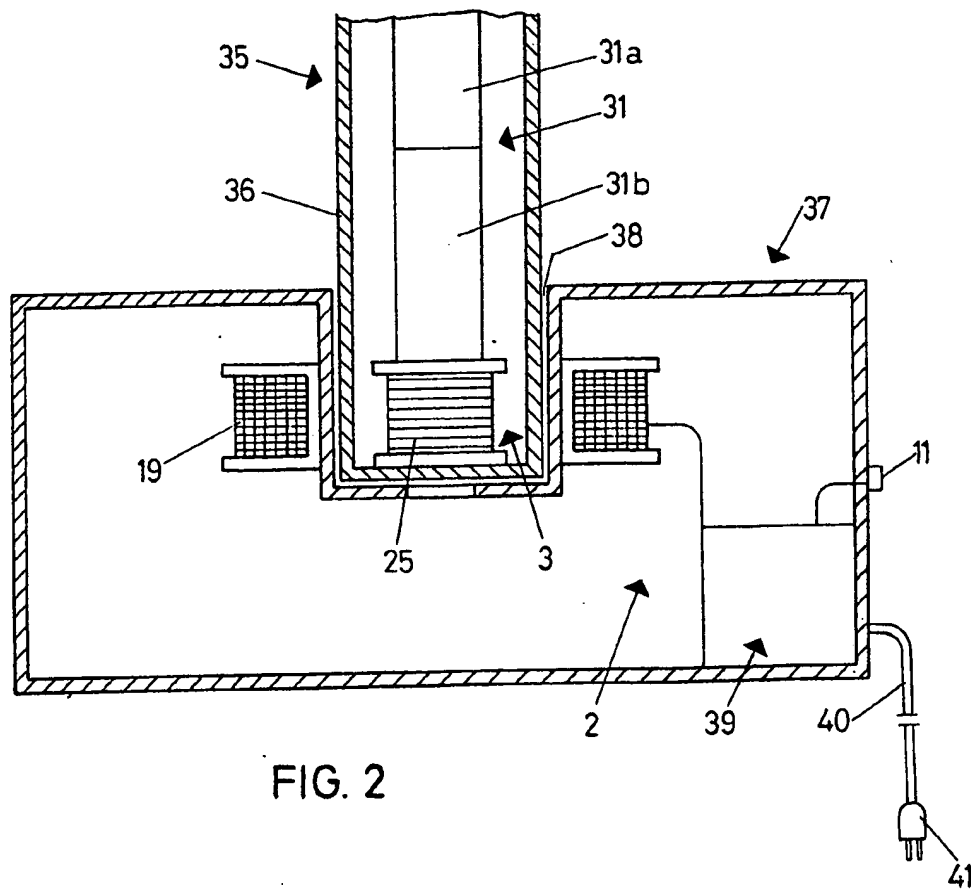


FIG. 1

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## SPECIFICATION

## Improvements in or relating to arrangements for charging storage batteries

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The present invention relates to an arrangement for charging storage batteries, and to an electrically driven dental care appliance, particularly a toothbrush, provided with a device of this kind, comprising at least one storage-battery cell as a supply source.

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Electrically driven toothbrushes comprising at least one storage-battery cell for feeding a drive motor for a bristle carrier are already known. When the toothbrush is not used the storage battery is recharged by means of a battery charger, which is entirely or partly accommodated in a holder for the toothbrush.

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In an arrangement disclosed in Swiss patent specification 425 719, there is an electrically conducting connection between the battery charger and the storage battery. For this purpose of the base of the toothbrush is provided with contacts which cooperate with opposite contacts in the holder. When the toothbrush is placed in the holder the storage battery is thus switched into the charging circuit. This arrangement has the disadvantage that the exposed contacts and opposite contacts are subject to the danger of fouling and oxidation. Constant maintenance is therefore necessary, as otherwise there is no guarantee that the storage battery will be perfectly recharged.

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It is also known to accommodate the charging circuit in the toothbrush instead of in the holder (see for example Swiss patent specification 463 457). The holder contains the primary winding — connected to a low-frequency alternating current voltage source (50 or 60 Hz) — of a transformer, the secondary winding of which is accommodated in the toothbrush. A rectifier is connected to this secondary winding. There is therefore an inductive coupling between the holder and the toothbrush via the transformer. Although there is no danger of fouling and oxidation, which would impair the mode of operation, in order to obtain a sufficiently large charging current the transformer windings must be dimensioned accordingly and wound onto an iron core. This results in a correspondingly bulky and heavy type of construction. Moreover, the charging procedure is accompanied by a considerable development of heat, which leads to a corresponding temperature rise both in the holder and in the toothbrush handle. This rise in temperature entails, *inter alia*, an undesirable reduction in the working life of the storage battery.

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According to the invention, there is provided an arrangement for charging one or more storage batteries, comprising a primary circuit for connection to a low-frequency alternating current voltage source and a secondary circuit which is inductively coupled to the primary circuit, is separable therefrom, and is provided with a charging circuit for at least one storage battery cell, the primary circuit comprising a circuit for producing a high-frequency alternating current voltage for transfer to the secondary circuit.

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It is possible thus to provide a reliable device for charging storage batteries of the above-mentioned type which is of simple design, is a space-saving and, as far as possible, light type of construction and enables perfect recharging to take place at all times, even when the voltage value of the alternating current voltage source varies within broad ranges.

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In contrast to the known arrangements, in which a low-frequency supply voltage is transformed from the primary to the secondary side, a high-frequency alternating current voltage, produced in the primary circuit, is transferred to the secondary circuit in the subject matter of the application. The direct current voltage obtained on the secondary side from this high-frequency alternating current voltage can be satisfactorily smoothed in a simple manner, i.e. by the actual storage battery. As the transmission of power from the primary circuit to the secondary circuit takes place at a high frequency, favourable coupling conditions between the two circuits result. The transformer used for the inductive coupling can therefore be small and ironfree. A compact and light type of construction is thus possible. Also, the magnitude of the low-frequency supply voltage can vary within a large range without the charging current falling to a value which is no longer adequate for completely recharging the storage battery.

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A free-running oscillator, which is fed from a rectifier circuit connected to the alternating current voltage source, is preferably used to produce the high-frequency alternating current voltage. The alternating current voltage rectified by this rectifier circuit is fed to a direct current converter, to the output of which the storage battery cell(s) is/are connected. This direct current converter has the special feature of comprising an ironfree transformer. When the secondary circuit is moved away from the primary circuit the direct current converter, i.e. the transformer thereof, is disconnected.

An embodiment according to claims 4 or 6-9 provides a particularly simple and reliably operative solution. The RC network serves to open and inhibit the transistor in the embodiment according to claim 6. Transformer feedback is not necessary.

Such a charging arrangement is particularly, but not exclusively, suitable for use with an electrically driven dental care appliance provided with at least one storage battery cell. The primary circuit of the charging device is accommodated in a holder in which, when not in use, the dental care appliance in which the secondary circuit is accommodated is inserted.

The invention will be further described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 shows a circuit diagram of a device for recharging storage batteries; and

Figure 2 is a purely schematic longitudinal section through an electrically driven toothbrush inserted in its holder.

Figure 1 shows in the form of a circuit diagram a battery charger which is used to recharge the storage battery of an electrically driven toothbrush. This battery charger 1 comprises a primary circuit 2 and a secondary circuit 3, inductively coupled to the prim-

any circuit. As will be explained in greater detail with reference to Figure 2, the secondary circuit 3 can be spatially separated from the primary circuit 2.

The primary circuit 1 comprises two input terminals 4 and 5, to which a low-frequency alternating current voltage, e.g. the power-supply voltage of 110 or 220 volts (50 or 60 Hz), is supplied. A resistor 6 and a capacitor 7 are connected in series to the terminal 4. The resistor 6 serves to limit the current when the device is switched on, while the capacitor 7 reduces the voltage. A resistor 8 is connected to the two terminals 4, 5 and serves as a discharge resistor for the capacitor 7. In order to enable the capacitor 7 to discharge when the primary circuit 2 is separated from the alternating current voltage supply source, a diode 9 is provided. A rectifier element 10 is connected in series with the capacitor 10 and the cathode of the rectifier element is connected to a light-emitting diode 11. Reference number 12 designates a filter capacitor, with which a Zener diode 13, which serves to stabilize the voltage, is connected in parallel. A reactance coil or choke 14, connected in series with the light-emitting diode 11, eliminates interference.

The rectifier element 10 forms, together with the filter capacitor 12 and the Zener diode 13, a rectifier circuit which rectifies the supply voltage U and is connected upstream of an oscillator 15, which is fed by this rectifier circuit. This oscillator 15 comprises a transistor 16, the base B of which is connected to a potential divider formed by resistors 17 and 18. This potential divider is used to determine the base potential. The collector K of the transistor 16 is connected at point P to an inductor 19, which is connected in series with the collector-emitter-path of the transistor 16. A capacitor 20 is connected in parallel with this collector-emitter-path and forms, together with the inductor 19, a series-oscillatory circuit 21. A resistor 22 is connected to the emitter E of the transistor 16 and a capacitor 23 for stabilising the emitter is connected in parallel with this resistor 22. The emitter E is therefore coupled to the negative pole of the rectifier circuit 10, 12, 13 via the RC network 22, 23, which opens and inhibits the transistor 16. The inductor 19 of the series-oscillatory circuit 21 forms the primary winding of an ironfree transformer 24, the secondary windings 25 of which forms part of the secondary circuit 3. The secondary circuit 3 is inductively coupled to the primary circuit 2 via the two transformer windings 19 and 25. The transformer 24 is disconnected when the secondary circuit 3 is moved away from the primary circuit 2.

A rectifier element 26 is connected to the secondary winding 25 of the transformer 24. The cathode of this rectifier element 26 is connected to a Zener diode 27 and to a diode 28. The cathode of the diode 28 is connected to a connection 29. The other ends of the secondary winding 25 and the Zener diode 27 are connected to a second connection 30. A storage battery 31, which may consist of one or a plurality of storage-battery cells or an accumulator, is connected to the connections 29 and 30.

The transformer 24 comprises a third winding 32, which is arranged in the primary circuit 2. The connections of this winding 32 are indicated by 33 and

34. The voltage which is induced in the winding 32 and which is greater than the voltage across the winding 19 is used in the present case to produce ozone, which serves to disinfect the toothbrush, its bristle carrier and the battery charger 1.

The battery charger 1 operates as follows: The low-frequency alternating current voltage U of, e.g. 220 volts, 50 Hz, which is supplied to the input terminals 4, 5, is rectified by the rectifier element 10 (half-wave rectification). The direct current voltage which is thus obtained is smoothed by the filter capacitor 12. As mentioned above, the Zener diode 13 stabilises the voltage. The free-running oscillator 15, which produces a high-frequency alternating current voltage in a manner known *per se*, is supplied with the direct current voltage produced in the rectifier circuit 10, 12, 13 and, as indicated above, the transistor 16 is periodically opened and closed by means of the RC network 22, 23. The frequency of this alternating current voltage preferably lies above the audible range, i.e. above 16 kHz. The alternating current voltage produced in the inductor 19 is transmitted via the transformer 24 to the secondary circuit 3 and is simultaneously transformed to a lower value required for recharging the storage battery 31. In addition, a higher voltage is induced in the third winding 32, as mentioned above. The transformer alternating current voltage is again rectified (half-wave rectification) by the rectifier element 26. A direct current voltage thus appears across the connections 29 and 30 of the battery charger 1. This direct current voltage is smoothed by the storage battery 1, so that no additional means need be provided for this smoothing procedure. The Zener diode 27 limits or reduces the charging current as soon as the charging voltage of the storage battery 31 has reached the desired value. The diode 28 prevents the storage battery 31 from discharging via the Zener diode 27.

Thus, the battery charger 1 essentially comprises a direct current converter, which is formed from an oscillator 15, the transformer 24, the rectifier 26 and the rectifier 10, which produces from the input alternating current voltage U a direct current voltage for feeding the direct current converter. The direct current converter has the special feature of comprising an ironfree or core-less transformer 24 and of being disconnected when the secondary part 3 is moved away from the primary part 2. The base B of the transistor 16 is not coupled to the transformer winding 19, as is usually the case, but to a potential divider 17, 18 for determining the base potential.

The use of the battery charger 1 in a tooth cleaning appliance will now be described with reference to Figure 2, which is a purely schematic drawing. The reference number 35 designates an electrically driven toothbrush, of which only the rear part, distant from a bristle carrier, is shown. The drive, which is not shown, of this toothbrush 35 may be constructed in a manner known *per se*. The storage battery 31 is disposed in the housing 36 of the toothbrush 35 and serves as a supply source for the drive motor of the bristle carrier. In the illustrated embodiment the storage battery 31 consists of two storage battery cells 31a and 31b connected in series. These storage

battery cells 31a 31b are, for example, conventional nickel-cadmium batteries. The secondary circuit 3 of the battery charger 1, of which only the secondary winding 25 of the transformer 29 is illustrated in Figure 2, is also disposed inside the housing 36. A holder 37, which is usually fixed, is provided to turn off the toothbrush 35 when it is not being used. This holder 37 is provided with a recess 38, in which, as illustrated, the toothbrush 35 is placed. The primary winding 19 of the transformer 24 extends around this recess and is arranged such that, when the toothbrush 35 is placed in the holder 37, the secondary winding 25 is disposed inside the primary winding 19. The third transformer winding 32, together with its connections 33, 34, is not shown in Figure 2. The other component parts of the primary circuit 2 — disposed in the holder 37 — of the battery charger 1 are not shown in detail in Figure 2, with the exception of the light emitting diode 11. These component parts are disposed in the block 39, which is only shown diagrammatically. The primary circuit 2 is supplied via a cable 40, which is provided at its end with a plug 41, which can be inserted in a plug socket. The light emitting diode 11, which is externally visible, lights up as soon as the primary circuit 2 is connected to an alternating current voltage source.

When the toothbrush 35 is inserted in the holder 27 when not in use, the storage battery cells 31a, 31b are recharged in the manner described with reference to Figure 1. The toothbrush 35 is permanently ready for use on account of this continuous recharging of the storage battery cells. As is known, the toothbrush 35 is removed from the holder 37 when it is to be used.

The connections 33, 34 of the transformer winding 32 are connected in a suitable manner to discharge electrodes, which are arranged in the holder but not shown, in order to produce ozone. The ozone which is thus produced then passes over the toothbrush 35 and, in particular, its bristle carrier and the holder 37, thus disinfecting these parts.

As indicated above, the transformer 24 may be ironfree and of a small size. This results in a reduction in the weight of the battery charger 1 and a compact design. The free-running oscillator 15 is of simple construction and reliable in operation. A feedback winding is not necessary. The battery charger 1 is therefore inexpensive to produce. A further advantage of the battery charger 1 lies in its negligible rise in temperature, which does not have an adverse effect on the working life of the storage battery 31. As is clearly shown in Figure 2, the windings 19 and 25 of the transformer 24 are separated by the wall of the recess 38 of the holder 37 and the wall of the housing 36 of the toothbrush 35. Conditions for the magnetic coupling between the primary and the secondary circuits 2, 3 are therefore, as such, very unfavourable. However, owing to the fact that the transfer from the primary circuit 2 to the secondary circuit 3 takes place at a high frequency, this disadvantage can be countered, i.e. the coupling conditions are improved.

If the battery charger 1 is supplied with an alternating current voltage of 110 V and 220 V, the charging current is high enough to efficiently charge the stor-

age battery 31. The battery charger 1 can therefore be connected both to a supply source of 220 V and one of 110V, without the necessity of using additional measures. The same battery charger 1 can therefore be used in countries with a different mains voltage.

This battery charger 1 is of course not only suitable for recharging storage batteries of a toothbrush. It can also be used with, for example, other dental or mouth care appliances such as massaging appliances for gums. Moreover, the battery charger 1 can also be used to recharge the storage batteries of other electrically driven hand-operated instruments which are not designed to clean and care for teeth. A razor is an example of a hand-operated instrument of this type.

Finally, it should be pointed out that the battery charger may be formed of parts other than those illustrated. For example, other suitable oscillators may also be used. The voltage induced in the tertiary winding 32 of the transformer 24 may also be used for purposes other than producing ozone.

The frequency of operation of the oscillator is substantially greater than mains frequency (50 Hz) and is preferably above the audible frequency range e.g. higher than 15 kHz. Operation at such frequencies permits greatly improved reactive coupling between the transformer windings. However, the frequency is preferably chosen to be less than that at which the "skin effect" becomes significant.

#### CLAIMS

1. An arrangement for charging one or more storage batteries, comprising a primary circuit for connection to a low-frequency alternating current voltage source and a secondary circuit which is inductively coupled to the primary circuit, is separable therefrom, and is provided with a charging circuit for at least one storage battery cell, the primary circuit comprising a circuit for producing a high-frequency alternating current voltage for transfer to the secondary circuit.

2. An arrangement as claimed in claim 1, in which the circuit for producing a high-frequency alternating current voltage comprises a free-running oscillator.

3. An arrangement as claimed in claim 2, including a rectifier circuit, which is connectable to the alternating current voltage source, for supplying the oscillator.

4. An arrangement as claimed in claim 2 or 3, in which the oscillator is an LC-oscillator with a series-oscillatory circuit.

5. An arrangement as claimed in claim 4, in which the inductor of the series-oscillatory circuit forms the primary winding of a transformer, which is ironfree and whose secondary winding is arranged in the secondary circuit, which includes a further rectifier.

6. An arrangement as claimed in claim 4 or 5, in which the oscillator comprises a transistor, the emitter or the collector of which is coupled to a pole of the rectifier circuit via an RC network.

7. An arrangement as claimed in claim 6, in which the collector or the emitter of the transistor is directly connected to the connection point between

the inductor and the capacitor of the series-oscillatory circuit.

8. An arrangement as claimed in claim 7, in which the collector-emitter-path of the transistor is  
5 connected in series with one oscillatory circuit element and in parallel with the other oscillatory circuit element.

9. An arrangement as claimed in any one of claims 6 to 8, in which the base of the transistor is  
10 connected to a potential divider.

10. An arrangement as claimed in any one of claims 1 to 9, in which a Zener diode is provided for interrupting charging or for reducing charging current once the charging voltage of the storage battery  
15 cell has reached a desired value.

11. An arrangement as claimed in claim 5, in which the transformer comprises a further winding arranged in the primary circuit.

12. An arrangement for charging a storage battery, substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

13. An electrically driven dental care appliance, such as a toothbrush, comprising at least one  
25 storage-battery cell as a supply source and including an arrangement as claimed in any one of the preceding claims for charging the storage-battery cell.

14. An appliance as claimed in claim 13, in which the secondary circuit of the battery charger is  
30 accommodated in the appliance and the primary circuit is accommodated in a holder for the appliance, the secondary winding of the transformer accommodated in the appliance being arranged inside the primary winding interposed in the primary circuit  
35 when the appliance is inserted in the holder.

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